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LAKE CHARLESTON, COLES COUNTY, ILLINOIS

Pacific Northwest Environmental Research Laboratory

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June 1975

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivded according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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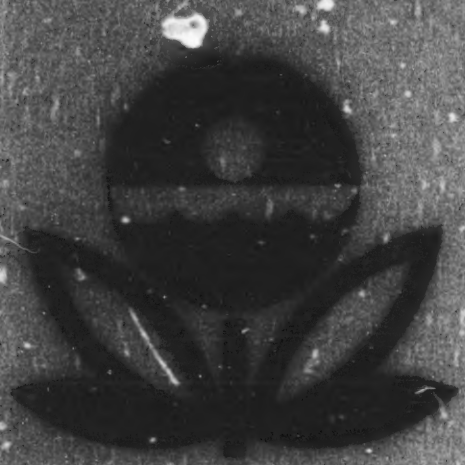

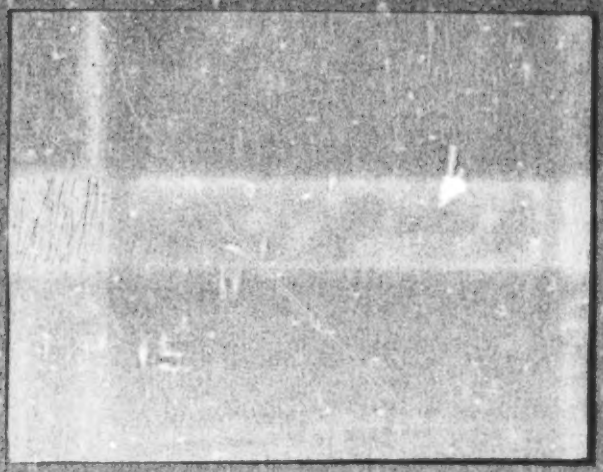

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REPORT
ON
LAKE CHARLESTON
COLES COUNTY
ILLINOIS
EPA REGION V
WORKING PAPER No. 299

WITH THE COOPERATION OF THE
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
AND THE
ILLINOIS NATIONAL GUARD
JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Illinois Environmental Protection Agency for professional involvement and to the Illinois National Guard for conducting the tributary sampling phase of the Survey.

Dr. Richard H. Briceland, Director of the Illinois Environmental Protection Agency; and Ronald M. Barganz, State Survey Coordinator, and John J. Forneris, Manager of Region III, Field Operations Section of the Division of Water Pollution Control, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

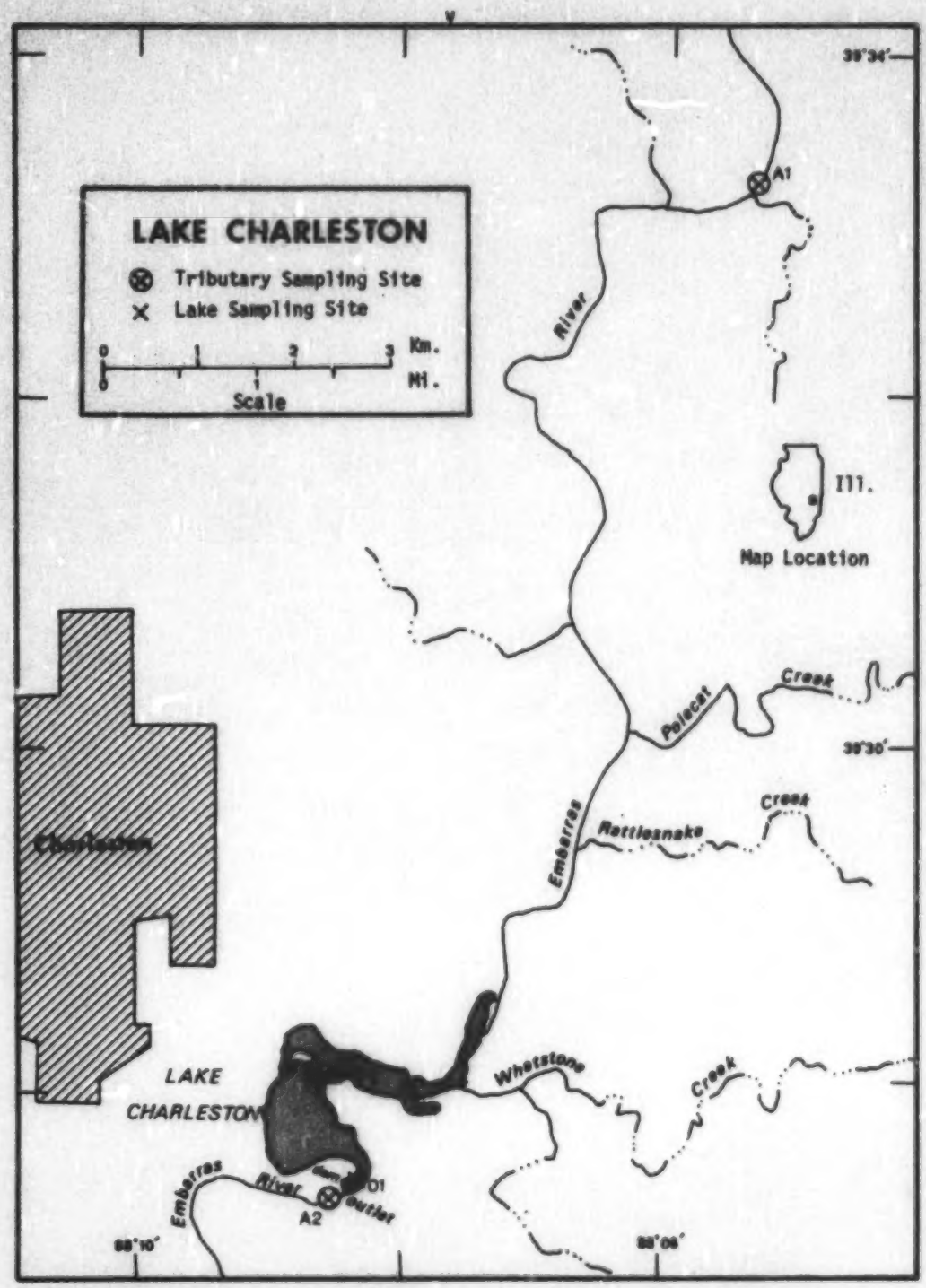
Major General Harold R. Patton, the Adjutant General of Illinois, and Project Officer Colonel Daniel L. Fane, who directed the volunteer efforts of the Illinois National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

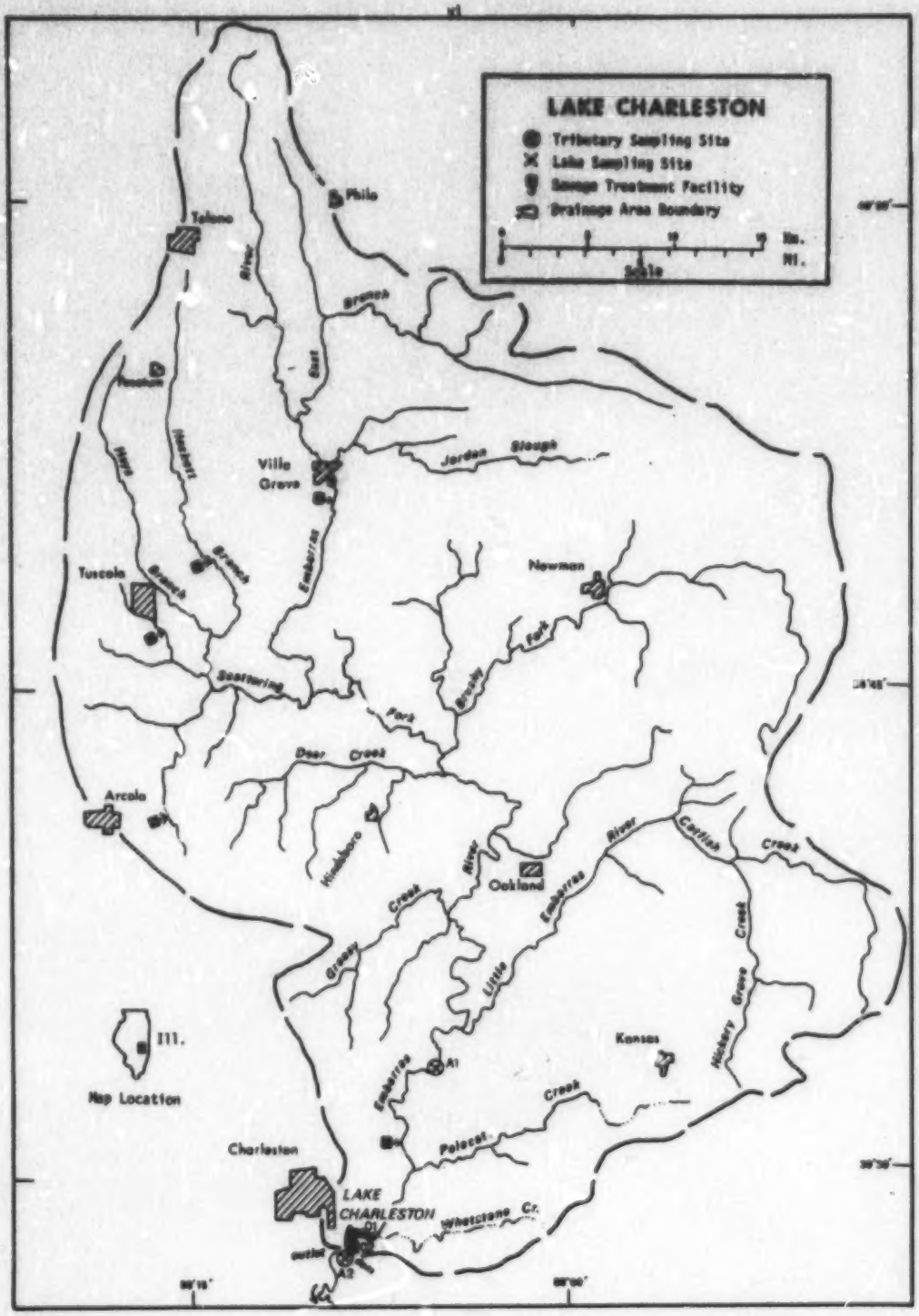
NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ILLINOIS

LAKE NAME	COUNTY
Baldwin	Randolph
Bloomington	McLean
Carlyle	Bond, Clinton, Fayette
Cedar	Lake
Charleston	Coles
Coffeen	Montgomery
Crab Orchard	Jackson, Williamson
Decatur	Macon
DePue	Bureau
East Loon	Lake
Fox	Lake
Grass	Lake
Highland Silver	Madison
Holiday	LaSalle
Horseshoe	Madison
Long	Lake
Lou Yaeger	Montgomery
Marie	Lake
Old Ben Mine	Franklin
Pistakee	Lake, McHenry
Raccoon	Marion
Rend	Franklin, Jefferson
Sangchris	Christian
Shelbyville	Moultrie, Shelby
Slocum	Lake
Springfield	Sangamon
Storey	Knox
Vandalia	Fayette
Vermilion	Vermilion
Wee Ma Tuk	Fulton
Wonder	McHenry


LAKE CHARLESTON
Tributary Sampling Site
Lake Sampling Site
0 1 2 3 Km.
0 1 Mi.
Scale
A1
A2
D1
Ill.
Map Location
River
Creek
Polecat
Rattlesnake
Embarras
Whetstone
Creek
Charleston
LAKE
CHARLESTON
Embarras
River
Outlet
39°34'
39°30'
88°10'
88°06'


LAKE CHARLESTON
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Mi.
Scale
Tolono
Philo
Fountain
Jordan Slough
Villa Grove
Tuscola
Newman
Scattering
Fork
Deer Creek
Arcola
Hindsboro
Oakland
Embarras River
Cattish Creek
Grassy Creek
Little
Hickory Grove Creek
Kansas
A1
Palecat Creek
Charleston
LAKE CHARLESTON
Whetstone Cr.
outlet
Ill.
Map Location

LAKE CHARLESTON

STORET NO. 1708

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Charleston is eutrophic. It ranked 25th in overall trophic quality when the 31 Illinois lakes sampled in 1973 were compared using a combination of six parameters*. Nineteen of the lakes had less median total phosphorus, 22 had less median dissolved phosphorus, 28 had less median inorganic nitrogen, seven had less mean chlorophyll a, and all of the other lakes had greater Secchi disc transparency.

Survey limnologists noted the occurrence of emergent aquatic vegetation along the shorelines near both sampling stations.

B. Rate-Limiting Nutrient:

The algal assay results indicate the lake was phosphorus limited at the time the sample was taken (05/07/73). The lake data also indicate phosphorus limitation; i.e., the mean N/P ratios were 32/1 or greater at all sampling times.

C. Nutrient Controllability:

1. Point sources--The phosphorus contribution of known point sources amounted to 13.7% of the total load reaching Lake Charleston during the sampling year. These sources include Arcola (3.7%), Cabot Carbon Company (0.2%), Tuscola

* See Appendix A.

North (2.6%), Tuscola South (3.2%), and Villa Grove (3.0%). Shoreline septic tanks were estimated to have contributed less than 0.1%.

The present phosphorus loading rate of 52.51 $g/m^2/yr$ is nearly 16 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic rate (see page 13). However, Vollenweider's model probably does not apply to water bodies with short hydraulic retention times, and the mean hydraulic retention time of Lake Charleston is a very short one day. Nonetheless, the existing trophic condition of the lake is evidence of excessive nutrient loads.

On the basis of Survey data, it appears that the trophic condition of Lake Charleston will continue to deteriorate unless the present phosphorus loading is reduced. Because of this, and because the lake is phosphorus limited, all phosphorus inputs should be minimized to the greatest practicable extent to reduce the rate of eutrophication.

It is noted that an apparent loss of phosphorus from the lake occurred during the sampling year. While phosphorus wash-out can occur following a substantial reduction of phosphorus inputs, no such input reduction was involved, and the

"loss" most likely was due to insufficient outlet sampling in relation to the very short hydraulic retention time.

2. Non-point sources--The phosphorus contribution of non-point sources accounted for 86.3% of the total load reaching the lake during the sampling year. The only measured tributary, the Embarras River, contributed 79.0%. The ungaged drainage area was estimated to have contributed 7.3% of the total phosphorus load.

The non-point phosphorus export rate of the Embarras River was 32 kg/km^2/yr (see page 12). This appears to be within the range expected for non-point sources in this area of Illinois and compares well with the export rates of the unimpacted tributaries of nearby Shelbyville Reservoir* (mean = 31 kg/km^2/yr; range of 20 to 44 kg/km^2/yr).

* Working Paper No. 315.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 1.45 kilometers².
2. Mean depth: 0.9 meters.
3. Maximum depth: >1.5 meters.
4. Volume: 1.305×10^6 m³.
5. Mean hydraulic retention time: 1 day.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km²)*	Mean flow (m³/sec)*
Embarras River	1,864.8	13.3
Minor tributaries & immediate drainage -	169.4	1.2
Totals	2,034.2	14.5

2. Outlet -

Embarras River	2,035.7**	14.5

C. Precipitation***:

1. Year of sampling: 155.7 centimeters.
2. Mean annual: 97.4 centimeters.

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† Table of metric conversions--Appendix B.
†† Forneris, 1973.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1975".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Charleston was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1 and 1.5 meters at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE CHARLESTON
STORET CODE 1708

PARAMETER	1ST SAMPLING (5/ 7/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 9/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/10/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	15.2 - 15.3	15.3	15.3	25.3 - 28.4	26.8	25.8	15.9 - 17.8	16.6	16.1
DISS OXY (MG/L)	9.0 - 9.2	9.1	9.1	6.6 - 7.0	6.8	6.8	7.4 - 8.4	7.9	7.9
CNDCTVY (MCRMHO)	600. - 610.	605.	605.	517. - 578.	548.	548.	497. - 988.	519.	508.
PH (STAND UNITS)	8.1 - 8.1	8.1	8.1	7.9 - 8.0	7.9	7.9	7.9 - 8.1	8.0	8.0
TOT ALK (MG/L)	144. - 178.	163.	164.	263. - 270.	237.	237.	173. - 305.	257.	288.
TOT P (MG/L)	0.106 - 0.116	0.112	0.112	0.160 - 0.168	0.164	0.164	0.172 - 0.229	0.207	0.221
ORTHO P (MG/L)	0.056 - 0.060	0.058	0.057	0.075 - 0.078	0.076	0.076	0.088 - 0.125	0.086	0.087
NO2+NO3 (MG/L)	0.010 - 0.280	0.090	0.075	3.960 - 4.590	4.275	4.275	2.250 - 2.640	2.480	2.318
AMMONIA (MG/L)	0.080 - 0.090	0.085	0.085	0.090 - 0.100	0.095	0.095	0.110 - 0.360	0.235	0.230
KJEL N (MG/L)	0.380 - 0.580	0.425	0.450	0.900 - 1.400	1.150	1.150	0.880 - 1.880	1.433	1.760
INORG N (MG/L)	0.180 - 0.280	0.175	0.180	4.080 - 4.680	4.378	4.378	2.590 - 2.980	2.713	2.680
TOTAL N (MG/L)	0.580 - 0.540	0.515	0.510	5.360 - 5.480	5.425	5.425	3.640 - 4.040	3.913	4.010
CHLRPYL A (UG/L)	2.5 - 2.8	2.6	2.6	11.6 - 19.0	15.3	15.3	11.2 - 24.9	18.0	18.0
SECCHI (METERS)	0.2 - 0.3	0.2	0.2	0.2 - 0.3	0.2	0.2	0.3 - 0.3	0.3	0.3

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal units per ml
05/07/73	1. Cryptomonas sp.	282
	2. Synedra sp.	84
	3. Flagellates	84
	4. Euglena sp.	56
	5. Pinnularia sp.	56
	Other genera	142
	Total	704
08/09/73	1. Flagellates	2,776
	2. Stephanodiscus sp.	882
	3. Melosira sp.	493
	4. Euglena sp.	337
	5. Actinastrum sp.	104
	Other genera	260
	Total	4,852
10/18/73	1. Euglena sp.	5,010
	2. Stephanodiscus sp.	1,160
	3. Phacus sp.	740
	4. Chlamydomonas sp.	550
	5. Pennate diatoms	370
	Other genera	1,140
	Total	8,970

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/07/73	01	2.8
	02	2.5
08/09/73	01	19.0
	02	11.6
10/18/73	01	24.9
	02	11.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.015	7.375	1.7
0.050 P	0.065	7.375	22.6
0.050 P + 1.0 N	0.065	8.375	21.8
1.0 N	0.015	8.375	2.8

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Lake Charleston was relatively high at the time the sample was collected (05/07/73). There was a significant increase in yield when orthophosphorus was added, but there was no significant change when only nitrogen was added. Based on these results, phosphorus limitation is indicated.

The lake data also indicate phosphorus limitation; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 32/1 or greater at all sampling times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Illinois National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi). Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Illinois District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the adjusted nutrient loads, in $kg/km^2/year$, at station A-1 and multiplying by the ZZ area in km^2.

The operator of the Arcola wastewater treatment plant provided monthly effluent samples and corresponding flow data. The operators of the Cabot Carbon Company, Savoy, Tuscola North, Tuscola South, and Villa

* See Working Paper No. 175.

Grove wastewater treatment plants did not participate in the Survey, and nutrient loads were estimated at 1.1[illegible] kg P and 3.401 kg N/capita/year.

A. Waste Sources:

1. Known municipal +

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Artola	2,200	act. sludge	1,377.4	Scattering Fork
Cabot Carbon Co., Tuscola (domestic)	125	act. sludge	47.3*	Scattering Fork
Savoy	650	act. sludge	246.0*	Embarras River
Tuscola North	1,760	trickling filter	666.2*	Hackett Branch
Tuscola South	2,150	act. sludge	813.8*	Scattering Fork
Villa Grove	2,050	act. sludge	775.9*	Embarras River

2. Known Industrial - None

+ Anonymous, 1972; Bargsnz, 1975.
* Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Embarras River	60,150	79.0
b. Minor tributaries & immediate drainage (non-point load) -	5,540	7.3
c. Known municipal STP's -		
Arcola	2,795	3.7
Cabot Carbon Co.	140	0.2
Tuscola North	1,995	2.6
Tuscola South	2,440	3.2
Villa Grove	2,325	3.0
Savoy	735	1.0
d. Septic tanks* -	<5	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	25	<0.1
Total	76,145	100.0

2. Outputs -

Lake outlet - Embarras River 78,115

3. Net annual P loss - 1,970 kg.

* Estimate based on 6 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Embarras River	3,137,940	90.8
b. Minor tributaries & immediate drainage (non-point load) -	285,190	8.3
c. Known municipal STP's -		
Arcola	8,600	0.2
Cabot Carbon Co.	425	<0.1
Tuscola North	5,985	0.2
Tuscola South	7,310	0.2
Villa Grove	6,970	0.2
Savoy	1,075	<0.1
d. Septic tanks* -	65	<0.1
e. Known industrial - None -	-	-
f. Direct precipitation** -	1,565	<0.1
Total	3,455,125	100.0

2. Outputs -

Lake outlet - Embarras River 2,862,870

3. Net annual N accumulation - 572,255 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Embarras River	32	1,683

* Estimate based on 6 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loading Rates:

In the following table, the existing phosphorus loading rates are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" rate is the rate at which the receiving water would become eutrophic or remain eutrophic; his "permissible" rate is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic rate would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	52.51	loss*	2,382.8	394.7

Vollenweider loading rates for phosphorus ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Charleston:

"Dangerous" (eutrophic rate)	3.30
"Permissible" (oligotrophic rate)	1.65

* There was an apparent loss of phosphorus during the sampling year. This may have been due to underestimation of the minor tributary and immediate drainage load or septic tank contributions but more likely was due to insufficient outlet sampling in relation to the very short one-day hydraulic retention time of the lake.

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1703	LAKE BLOOMINGTON	0.050	5.730	464.667	26.200	14.000	0.020
1706	LAKE CARLYLE	0.084	1.270	477.609	17.367	11.000	0.032
1708	LAKE CHARLESTON	0.160	4.680	490.667	12.000	8.400	0.065
1711	COFFEEN LAKE	0.032	0.260	456.222	7.700	14.900	0.012
1712	CRAB ORCHARD LAKE	0.082	0.[illegible]90	482.222	59.867	13.600	0.0[illegible]3
1714	LAKE DECATUR	0.129	3.750	479.571	43.800	14.500	0.062
1725	LONG LAKE	0.704	1.190	482.667	49.333	8.000	0.398
1726	LAKE LOU YAEGER	0.106	1.680	489.583	10.662	11.400	0.076
1727	LAKE MARIE	0.090	0.370	467.667	39.533	14.700	0.057
1733	PISTAKEE LAKE	0.283	0.370	485.667	75.867	7.000	0.062
1735	REND LAKE	0.071	0.210	471.500	23.533	12.700	0.012
1739	LAKE SHELBYVILLE	0.062	3.290	461.333	17.161	14.000	0.019
1740	SILVER LAKE (HIGHLAND)	0.226	0.970	489.500	5.822	14.000	0.057
1742	LAKE SPRINGFIELD	0.100	3.265	483.365	13.013	10.000	0.050
1748	VERMILION LAKE	0.109	4.695	481.500	31.150	14.200	0.050
1750	WONDER LAKE	0.426	0.890	486.000	98.533	7.000	0.132
1751	LAKE STORY	0.072	2.510	459.333	17.250	14.000	0.021
1752	DEPUE LAKE	0.438	4.050	490.000	58.833	7.600	0.276
1753	LAKE SANGCHRIS	0.050	1.970	475.417	19.292	14.500	0.009
1754	LAKE HOLIDAY	0.167	3.135	485.167	51.217	7.200	0.046
1755	FOX LAKE	0.219	0.375	486.167	63.850	8.000	0.083
1756	GRASS LAKE	0.381	0.020	481.000	83.500	5.900	0.093
1757	EAST LOON LAKE	0.076	0.120	450.000	22.300	14.900	0.01[illegible]
1758	SLOCUM LAKE	0.865	0.200	487.333	221.100	5.600	0.362
1759	CEDAR LAKE	0.029	0.170	480.333	5.767	12.000	0.013
1761	LAKE WEMATUK	0.069	1.770	466.333	7.967	14.500	0.031
1762	RACCOON LAKE	0.106	0.310	484.333	19.217	13.000	0.02[illegible]
1763	BALDWIN LAKE	0.044	0.140	461.167	11.333	13.200	0.007

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500- MEAN SEC	MEAN CHLORA	13- MIN DO	MEDIAN DISS ORTHO P
1764	LAKE VANDALIA	0.116	0.480	478.111	11.278	14.800	0.023
1765	OLD BEN MINE RESERVOIR	0.930	0.205	478.333	31.433	11.200	0.575
1766	HORSESHOE LAKE	0.127	0.785	482.833	182.250	6.600	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD-MEAN SEC	MEAN CHLORA	1S-MIN DO	MEDIAN DISS INTHO P	INDEX NO.
1703	LAKE BLOOMINGTON	88 (26)	0 (0)	80 (24)	47 (14)	13 (2)	68 ([illegible])	296
1706	LAKE CARLYLE	63 (19)	40 (12)	63 (19)	63 (19)	63 (19)	53 ([illegible])	348
1708	LAKE CHARLESTON	37 (11)	7 (2)	0 (0)	77 (23)	77 (23)	27 (8)	225
1711	COFFEEN LAKE	97 (29)	77 (23)	93 (28)	93 (28)	2 (0)	92 (27)	494
1712	CRAB ORCHARD LAKE	67 (20)	90 (27)	43 (13)	20 (6)	42 (12)	88 (25)	367
1714	LAKE DECATUR	40 (12)	13 (4)	53 (16)	33 (10)	30 (8)	32 (9)	201
1725	LONG LAKE	7 (2)	43 (13)	40 (12)	30 (9)	72 (21)	3 (1)	195
1726	LAKE LOU YAEGER	30 (9)	37 (11)	7 (2)	87 (26)	57 (17)	23 (7)	241
1727	LAKE MARIE	60 (18)	60 (20)	73 (22)	37 (11)	23 (7)	42 (12)	303
1733	PISTAKEE LAKE	27 (8)	60 (20)	23 (7)	13 (4)	90 (27)	32 (9)	253
1735	REND LAKE	77 (23)	80 (24)	70 (21)	50 (15)	53 (16)	92 (27)	422
1739	LAKE SHELBYVILLE	83 (25)	17 (5)	83 (25)	70 (21)	13 (2)	73 (22)	339
1740	SILVER LAKE (HIGHLAND)	20 (6)	47 (14)	10 (3)	97 (29)	13 (2)	42 (12)	229
1742	LAKE SPRINGFIELD	53 (16)	20 (6)	33 (10)	73 (22)	67 (20)	37 (11)	283
1748	VERMILION LAKE	50 (15)	3 (1)	47 (14)	43 (13)	37 (11)	47 (14)	227
1750	WONDER LAKE	13 (4)	50 (15)	20 (6)	7 (2)	80 (24)	13 ([illegible])	183
1751	LAKE STORY	73 (22)	27 (8)	90 (27)	67 (20)	13 (2)	63 (19)	333
1752	DEPUE LAKE	10 (3)	10 (3)	3 (1)	23 (7)	83 (25)	10 (3)	139
1753	LAKE SANGCHRIS	88 (26)	30 (9)	67 (20)	57 (17)	30 (8)	97 (29)	369
1754	LAKE HOLIDAY	33 (10)	23 (7)	27 (8)	27 (8)	87 (26)	5[illegible] (15)	267
1755	FOX LAKE	23 (7)	63 (19)	17 (5)	17 (5)	72 (21)	20 (6)	212
1756	GRASS LAKE	17 (5)	53 (16)	50 (15)	10 (3)	97 (29)	17 (5)	244
1757	EAST LOON LAKE	70 (21)	100 (30)	97 (29)	53 (16)	2 (0)	77 (23)	399
1758	SLOCUM LAKE	3 (1)	87 (26)	13 (4)	0 (0)	100 (30)	7 (2)	210
1759	CEDAR LAKE	100 (30)	93 (28)	100 (30)	100 (30)	50 (15)	85 (25)	526
1761	LAKE WENATUK	80 (24)	33 (10)	77 (23)	90 (27)	30 (8)	57 (17)	367
1762	RACCOON LAKE	57 (17)	73 (22)	30 (9)	60 (18)	42 (12)	68 (20)	330
1763	BALDWIN LAKE	93 (28)	97 (29)	87 (26)	80 (24)	47 (14)	100 (30)	504

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD- MEAN SEC	MEAN CHLORA	1S- MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1764	LAKE VANDALIA	47 (14)	60 (18)	60 (18)	83 (25)	13 (2)	66 (18)	323
1765	OLD BEN MINE RESERVOIR	0 (0)	83 (25)	57 (17)	40 (12)	60 (18)	0 (0)	240
1766	HORSESHOE LAKE	43 (13)	57 (17)	37 (11)	3 (1)	93 (28)	80 (24)	315

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1759	CEDAR LAKE	528
2	1763	BALDWIN LAKE	504
3	1711	COFFEEN LAKE	454
4	1735	REND LAKE	422
5	1757	EAST LOON LAKE	399
6	1753	LAKE SANGCHRIS	369
7	1761	LAKE WENATUK	367
8	1712	CRAB ORCHARD LAKE	347
9	1706	LAKE CARLYLE	345
10	1739	LAKE SHELBYVILLE	339
11	1751	LAKE STORY	333
12	1762	RACCOON LAKE	330
13	1764	LAKE VANDALIA	323
14	1766	HORSESHOE LAKE	313
15	1727	LAKE MARIE	303
16	1703	LAKE BLOOMINGTON	296
17	1742	LAKE SPRINGFIELD	283
18	1733	PISTAKEE LAKE	253
19	1754	LAKE HOLIDAY	247
20	1756	GRASS LAKE	240
21	1726	LAKE LOU YAEGER	241
22	1765	OLD BEN MINE RESERVOIR	240
23	1740	SILVER LAKE (HIGHLAND)	229
24	1748	VERMILION LAKE	227
25	1704	LAKE CHARLESTON	225
26	1755	FOX LAKE	212
27	1758	SLOCUM LAKE	210
28	1714	LAKE DECATUR	201

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
29	1725	LONG LAKE	195
30	1750	WONDER LAKE	183
31	1752	DEPUE LAKE	139

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR ILLINOIS 10/23/75

LAKE CODE 1708 LAKE CHARLESTON

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 2035.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1708A1	1864.8	13.79	18.81	23.73	25.63	26.73	14.38	9.37	5.13	3.94	4.93	6.88	6.18	13.38
1708A2	2035.7	15.66	19.68	25.94	27.30	29.17	15.72	10.25	5.69	4.36	5.44	7.36	6.86	14.84
1708ZZ	170.9	1.27	1.59	2.21	2.27	2.44	1.33	0.88	0.54	0.42	0.51	0.68	0.76	1.24

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2035.7
SUM OF SUB-DRAINAGE AREAS = 2035.7

TOTAL FLOW IN = 174.91
TOTAL FLOW OUT = 174.91

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1708A1	6	73	39.88	2	16.54				
	7	73	20.78	8	10.39				
	8	73	7.08	5	13.17				
	9	73	2.49	10	3.86				
	10	73	5.38	10	7.93				
	11	73	6.34	4	4.76				
	12	73	47.86	1	30.64				
	1	74	102.22	5	34.76				
	2	74	37.66	2	48.14				
	3	74	30.51	16	56.92				
	4	74	39.64	6	48.14				
	5	74	66.98	4	16.83				
1708A2	6	73	42.48	2	18.67				
	7	73	22.74	8	11.38				
	8	73	7.82	5	14.55				
	9	73	2.75	10	3.40				
	10	73	5.92	10	8.75				
	11	73	6.97	4	5.21				
	12	73	52.39	1	32.85				
	1	74	111.57	5	37.38				
	2	74	41.06	2	52.67				
	3	74	41.91	16	62.38				
	4	74	43.04	6	52.39				
	5	74	71.92	4	17.58				
1708ZZ	6	73	3.40	2	1.53				
	7	73	1.95	8	0.99				
	8	73	0.74	5	1.39				
	9	73	0.25	10	0.34				
	10	73	0.54	10	0.82				
	11	73	0.62	4	0.45				
	12	73	4.53	1	2.88				
	1	74	9.34	5	3.11				
	2	74	3.48	2	4.53				
	3	74	3.48	16	5.38				
	4	74	3.48	6	4.25				
	5	74	5.95	4	1.47				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/10/23

176801
39 27 30.0 088 08 25.0
LAKE CHARLESTON
17029 ILLINOIS

11EPALES
3

2111202
0007 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00665 PHOS-TOT MG/L P
73/05/07	16 30	0000	15.3		10	600	8.10	170	0.090	0.500	0.010	[illegible]
	16 30	0004	15.3	9.2		600	8.10	155	0.090	0.500	0.010	[illegible]
73/08/09	10 50	0000	26.4	7.8	10	517	8.00	203	0.100	1.400	3.900	[illegible]
73/10/18	13 45	0000	16.1		10	595	8.10	200	0.290	1.700	2.310	[illegible]
	13 45	0005	15.9	8.4		497	8.00	275	0.300	1.600	2.290	[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/07	16 30	0000	0.114	2.8
	16 30	0004	0.116	
73/08/09	10 50	0000	0.160	19.8
73/10/18	13 45	0000	0.172	24.9
	13 45	0005	0.221	

STORET RETRIEVAL DATE 75/10/23

170662
39 28 10.0 088 08 30.0
LAKE CHARLESTON
17029 ILLINOIS

11EPALES
3

21111202
0007 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOSPHUS ORTHO MG/L P
73/05/07	16 51	0000	15.3		8	610	8.10	164	0.050	0.400	0.140	0.000
	16 50	0005	15.2	9.0		610	8.10	170	0.060	0.300	0.090	0.000
73/08/09	11 05	0000	25.3	6.6	8	578	7.90	270	0.090	0.900	0.000	0.070
73/10/18	14 00	0000	17.8	7.4	10	555	7.90	305	0.110	0.800	0.040	0.105

27

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/07	16 50	0000	0.106	2.5
	16 50	0005	0.111	
73/08/09	11 05	0000	0.168	11.6
73/10/18	14 00	0000	0.229	11.2

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 75/10/23

1708A1
39 33 20.0 088 05 27.0
EMBARRAS RIVER
17027 15 TOLEDO
I/LAKE CHARLESTON
AIRTIGHT BRDG 5 MI NE OF CHARLESTON
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/02	14 14		7.700	2.800	0.096	0.080	0.135
73/07/08	10 00		8.400	2.900	0.074	0.081	0.175
73/08/05	09 30		5.000	2.700	0.310	0.089	0.125
73/09/10	09 00		6.600	2.040	0.140	0.040	0.110
73/10/14	09 50		2.020	1.350	0.252	0.080	0.220
73/11/04	09 00		3.800	1.300	0.390	0.250	0.315
73/12/01	13 00		6.500	0.300	0.116	0.080	0.250
74/01/04	13 30		8.100	0.300	0.048	0.052	0.065
74/02/02	14 15		7.700	2.500	0.095	0.060	0.110
	14 40		7.000	0.300	0.035	0.065	0.105
74/03/16	13 30		7.200	0.900	0.070	0.060	0.175
74/04/06	13 00		6.720	0.800	0.045	0.055	0.135
74/05/04	15 00		6.400	0.700	0.055	0.052	0.135

29

STORET RETRIEVAL DATE 75/12/23

1708A2
39 27 30.0 000 00 40.0
EMBANNAS RIVER
17 15 TOLEDO
O/LAKE CHARLESTON
ST RD 130 BRDG JUST BELO RIVERVIEW DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/02	15 00		6.600	1.540	0.100	0.075	0.180
73/07/08	10 30		4.000	0.980	0.070	0.070	0.145
73/08/05	10 20		4.600	2.480	0.270	0.089	0.150
73/09/10	09 45		1.140	2.280	0.230	0.078	0.195
73/10/14	08 30		3.500	0.450	0.050	0.150	0.210
73/11/04	10 00		2.600	1.050	0.105	0.084	0.175
73/12/01	13 45		6.400	0.100K	0.044	0.088	0.270
74/01/05	13 30		8.000	0.300	0.044	0.052	0.065
74/02/02	13 50		7.200	0.300	0.050	0.065	0.095
	15 00		7.200	1.400	0.345	0.065	0.135
74/03/16	11 45		6.400	0.900	0.055	0.060	0.180
74/04/06	12 30		6.800	0.800	0.040	0.055	0.130
74/05/04	15 00		6.500	1.100	0.065	0.055	0.150

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/10/23

1708AA AS1708AA P002200
39 41 00.0 088 15 28.0
CITY OF ARCOLA
17 250 DECATUR
T/LAKE CHARLESTON
EMBARASS RIVER
11EPALES 2141204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/07/10 CP(T)- 73/07/10	07 00 16 00		0.160	16.800	5.700	7.700	8.900	0.238	0.296
73/08/14 CP(T)- 73/08/14	07 00 16 00		0.050	10.500	0.610	2.100	12.600	0.320	0.441
73/09/11 CP(T)- 73/09/11	07 00 16 00		0.024	45.000	3.800	5.100	5.900	0.248	0.341
73/12/13 CP(T)- 73/12/13	07 00 16 00		0.330	14.500	2.600	3.400	4.200	0.374	0.222
74/01/17 CP(T)- 74/01/17	07 00 16 00		5.040	24.000	0.070	4.100	5.100	0.250	0.492
74/04/09 CP(T)- 74/04/09	07 00 16 00		5.600	2.800	0.050K	1.250	2.200	0.518	0.516
74/04/23 CP(T)- 74/04/23	07 00 16 00		0.240	10.000	0.120	2.200	3.150	0.540	0.420
74/07/24 CP(T)- 74/07/24	07 00 16 00		0.560	25.000	7.800	7.000	9.000	0.150	0.183

K VALUE KNOWN TO BE
LESS THAN INDICATED